Chapter 17
Students' Reflections

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Abstract Sixteen essays written by the students who participated in the PAGES 2011 Summer School are presented. They were written stimulated by the lectures and students' discussions during the Summer School. Their essays focus on issues observed at the interface between technology and society, such as risk/cost versus benefit, rationality and irrationality, communication, and the role of nuclear engineers.

Keywords Students' essays · PAGES 2011 summer school · GoNERI · Interface between technology and society · Roles of engineers

17.1 Format for Students' Discussion at the Summer School

When the 2011 PAGES Summer School was organized, the central consideration was providing students with sufficient time and guidance for discussions. It was deemed crucial to make students' discussions integrative and free of stereotypical perceptions from their own fields.

Morning discussions spanned 30 min, and afternoon sessions included a 90-min "reflection and discussion" slot. In these latter sessions, discussants were designated to lead the discussion; three postdoctoral researchers, Dr. Mary Sunderland, Dr. Robert A. Borrelli, and Dr. Takuji Oda, took on this role, as well as contributing chapters to this book. They encouraged interaction among participants by proposing points to be explored and steering discussion as needed. Table 17.1 is the list of lectures and lecturers. Stemming from these lectures, students were encouraged to join in discussion with their fellow students and lecturers.

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J. Ahn et al. (eds.), *Reflections on the Fukushima Daiichi Nuclear Accident*,
DOI 10.1007/978-3-319-12090-4_17

Table 17.1 List of lecture(r)s at PAGES 2011 Summer School and questions provided by lecturers

8/1 Mon.	Scientific analysis of radiation contamination at the area around the Fukushima-Daiichi Nuclear Power Station, Prof. Satoru Tanaka (Univ. of Tokyo) 1. How can we improve the transmission of information? 2. How can we accelerate decontamination outside of the reactors site and people's returning home?
	Physics of Fukushima damaged reactors and its preliminary lessons, Prof. Naoyuki Takaki (Tokai Univ., Japan) 1. How serious is the consequence of Fukushima accident? Consider from various views, such as the number of deaths; health risk for current and future generations; fears and inconvenience imposed on the public; impact on economy, etc. Is it unacceptable even if benefit (energy) derived from it is considered? 2. If society allows continuous use of nuclear, what attributes should a nuclear system in the new era have? Give a concrete image/concept of such a new nuclear system (e.g., reactor plant and its fuel cycle)
	Radiation safety regulation under emergency condition, Prof. Toshiso Kosako (Univ. of Tokyo) 1. What do we think about the emergency workers dose limit? (Cf. Japanese regulation: 100 mSv, changed to 250 mSv in this period) What happened to the remediators' working conditions when dose limits are exceeded while working on emergency tasks? 2. What do you think about evacuation for the general public under a nuclear emergency situation? (Cf. Japanese regulation: 10 km as a typical evacuation zone) What kind of arrangement is possible after using SPEEDI code? The arranged area should be circle or fan-shape? 3. What is the main reason for administration of iodine pills to children? (Japanese regulation: about 40 mg for children) 4. What kind of arrangement is effective for making surface contamination maps? Use only radiation monitoring? 5. What do you think about the radiation level for school playgrounds? What is your idea for a dose rate guideline? 6. Is it possible to remove contaminated soil by slicing off 5 cm for the decontamination of radionuclide in all areas of Fukushima prefecture? 7. What method exists for the control of foodstuffs after the accident? Please explain your idea
8/2 Tue.	Impact of Fukushima for reactor design practice, Prof. Per Peterson (UC Berkeley) 1. Discuss "backfitting" policy (10 CFR50.109 in the U.S.) which establishes the types of changes that a national regulatory authority can require for existing nuclear facilities. Consider analogies to policies for when existing buildings must be upgraded to meet new building code requirements, and requirements for when automobiles and consumer products must be recalled for repair or replacement. Discuss the societal tradeoffs in requiring backfitting (balance of the cost of backfitting against the benefit of improved safety). Discuss how backfitting policy might affect decisions to introduce improvements in new reactor designs 2. Considering the vertical axis of the Farmers chart for the frequency of internal initiating events, discuss the commercial risks associated with introducing different fuels and materials in new reactor designs, and how such risks can be reduced

Table 17.1 (continued)

	Ethics, risk and uncertainty: reflections on Fukushima and beyond, Prof. William E. Kastenberg (UC Berkeley) 1. Are risk analysis methodologies robust enough to assess and manage the risk of core-melt accidents, such as at Fukushima, i.e. could the accident have been predicted or mitigated? 2. Was emergency planning and emergency response adequate enough to protect public health and safety both before and after the Fukushima accident? 3. Was there an adequate "safety culture" in place prior to and following the accident? 4. What would it take to improve the quality of risk analysis and emergency planning so that the loss of public confidence could have been avoided?
8/3 Wed.	"Failure" of regulation and issues in public policy studies, Prof. Hideaki Shiroyama (Univ. of Tokyo) 1. Who and what mechanism should play roles for searching and integrating diverse knowledge that is necessary for managing complex system? 2. What is the way for strengthening regulatory capacity? Or how to keep civilian nuclear regulatory power without military use (which provide fund and personnel)? Or is it possible to restructure voluntary safety capability? 3. Is it possible and effective to organize and implement nuclear safety research separated from nuclear research and development in general?
	The structural failure of the science-technology-society interface: a hidden accident long before Fukushima, Prof. Miwao Matsumoto (Univ. of Tokyo) 1. How was the mutual relationship between success and failure in the little known but serious accident happened during wartime mobilization? 2. How do you think is the mutual relationship between success and failure in the Fukushima accident? 3. What are the similarity and the difference between the accident during wartime mobilization and the Fukushima accident in terms of the mutual relationship between success and failure in the science-technology-society interface? 4. What do you think about possibility of detecting the cause of structural failure in advance and incorporate structural remedies, if there are, in your design practice?
	Three mile Island and Fukushima: some reflections on the history of nuclear power, Dr. J. Samuel Walker (Former USNRC Historian) 1. What are the most important lessons of Three Mile Island? 2. To what extent would a good understanding of the lessons of Three Mile Island have been helpful in the response to Fukushima? Would they have been useful in reacting promptly and as effectively as possible to the technical failures caused by the earthquake and tsunami? Would they have been helpful in responding to media questions and public fears about the effects, real and potential, of the accident? 3. Is it ever appropriate to intentionally provide information to the public about a nuclear accident that is incomplete, overly optimistic, or misleading? If so, under what conditions? 4. How do authorities deal with the problem of providing accurate and up-to-date information when their own knowledge of the situation after a nuclear plant accident is fragmentary? 5. Are the benefits of nuclear power worth the risks?

Table 17.1 (continued)

8/4 Thu.	Engineers in organization, in industry and in society: ethical considerations, Prof. Jun Fudano (Kanazawa Institute of Tech., Japan) 1. Compare and contrast the Code of Ethics of the American Nuclear Society (http://www.new.ans.org/about/coe/) and its counterpart in Japan, namely, the Code of Ethics of the Atomic Energy Society of Japan (http://www.aesj-ethics.org/02_/02_03_/). Also make a list of values, in order of priority, which are stipulated in each code. 2. Which ethical principles have been violated in the case of the Fukushima Nuclear Accident? 3. Reflecting on the Fukushima Accident and referring to the above codes and any appropriate ones, write your own code of ethics (Cite all codes you used.) 4. Explain, to laypeople, why engineers, especially, nuclear engineers, have special responsibility
	Long-Term Energy and Environmental Strategy, Prof. Yasumasa Fujii (Univ. of Tokyo) 1. When should we use Uranium resource in the long-term perspective of human civilization? 2. To what extent can we depend on intermittent renewable energy?
	[After-dinner Talk] From Fukushima To the World: How to Learn from the Experience in Japan, Dr. Tatsujiro Suzuki (Atomic Energy Commission of Japan)

Note affiliations are as of August 2011

Students formed small groups (about 4–6 people) during the group discussion/work sessions. This grouping was undertaken by the students themselves, and was based on shared interests. Students repeatedly held discussions within the groups and formulated tentative answers to some of the questions posed by lecturers, as well as other questions they found important in the larger group discussions.

To accelerate interactions among student participants, "student session" slots were scheduled for the evenings of August 2 and 3. In these sessions, the students gave oral presentations that introduced their own, often quite intensive, activities after the Fukushima accident, described their thoughts regarding the event, and sought feedback from other students and lecturers.

The four days of lectures and discussions then culminated in student presentations on Friday, August 5. The self-organized student groups gave presentations about their questions and answers and received feedback from lecturers and other participants. The summer school closed with a session of reflections by the lecturers and organizers and a general discussion with the student participants.

All students were required after completing the school to submit individual essays that described their own answers to the questions they chose to focus on, based on all of the discussions they participated in, including the concluding sessions.

The rest of this chapter consists of essays written by the participating students. Note that some of these essays may seem ambiguous and confusing, which results from two reasons. One obvious reason is that some students were not native English speakers. The Editor has tried to reduce this kind of ambiguity. The second and more fundamental reason is because of the complexity and ambiguity inherent in the topics themselves. The Editor intentionally left this type of ambiguity. Actually, these two kinds of ambiguity are not so clearly separable. The Editor hopes to have accomplished this complex task, and to successfully convey to the reader the students' struggles to seek their answers.

17.2 Students' Essays

17.2.1 Thoughts on Emergency Workers' Dose Limit, by Toshiyuki Aratani, the University of Tokyo

I was able to think about various things as I participated in the PAGES 2011 Summer School. While reflecting on the discussions at the summer school, I selected for my response the first question by Prof. Kosako: "What do we think about the emergency workers dose limit? (Cf. Japanese regulation: 100 mSv, changed to 250 mSv during this period) What happened to the remediators' working conditions when dose limits are exceeded while working on emergency tasks?".

The optimization of workers' radiation dose should be considered. It is unfortunate that while doing emergency work, workers are exposed to large doses. The emergency worker will not be able to work longer in the place when he has exceeded the dose limit. Because the accident has been protracted, skilled workers who were initially on the scene were forced to leave because they exceeded the dose limit. Therefore, further recovery work was in the hands of less skilled workers. It is expected that the accident's impact will result in a prolonged situation in which the public would have a greater amount of exposure. In addition, later work is also problematic for workers who exceed the dose limit. So, an emergency dose limit should not be set at too low a value, and policy decisions should be made on the optimization premise.

100 mSv was changed to 250 mSv in this period, in line with the ICRP2007 recommendation written as follows: ~100 mSv—a dose for those engaged in emergency rescue; 500 mSv or 1000 mSv—doses to avoid deterministic effects may occur, as the dose of those engaged in emergency rescue; nothing—indicating that the lifesaving benefits outweigh the risks to life of others.

Evidence shows that there is not a clear current value. First of all, if we have adopted the recommendations of the ICRP value for other regulations, the amount of exposure in an emergency should also be adopted.

I have heard that nuclear power is earth-friendly, low cost. This may be right from one side, but from another side this might not be so. While the world is still actively using coal power generation, nuclear power is better to deal with global warming. With the end of the depreciation on a nuclear plant such as Fukushima Daiichi, the fixed costs become significantly less, which means more inexpensive power unmatched by any other means. However, an old power plant like a Fukushima Daiichi can be a defense against disasters. I think it is probably safe even if more disasters occur. Even then, we must consider the mind-boggling issue of the destination for radioactive waste. And we must be prepared for ruin of the land and its enormous cost. Each technology has advantages and disadvantages. Though inexpensive, fears about nuclear power have called for stopping its use from a simplistic point of view. But there is the risk that we will not find any other alternative energy. Thus, gridding and distributed energy development firms feel it necessary to increase research and development budgets.

17.2.2 The Role of Engineers in Democratic Societies, by Christian Di Sanzo, University of California, Berkeley

After the Fukushima accident, the governments of Germany and Switzerland have planned a phase-out of nuclear energy, while France and U.S. have decided to have little or no debate on the public's concerns about nuclear energy. Other countries, such as Italy, have chosen the way of a national referendum on energy policy which led to halt of the nuclear program.

What should be the role of engineers and what are its limitations in the decision making process?

In simple terms, we could say that engineers should honestly evaluate the technological performance, technological costs, and the risks associated with the use of energy technologies. This information should be conveyed to policy makers who should use their judgment to evaluate the social/economic benefits and then choose a solution for the benefit of the public. However, in this process it is of crucial importance to understand the information that is conveyed by the engineers. An energy analysis always has some uncertainties, e.g., in the numerical data available and in the expected cost of technologies. Consequently, all analysis should be conveyed to the policy makers with the related uncertainties. However, since policy makers often do not have a complete (all energy) background, it is hard for them to understand the real meaning of uncertainties, and they could often, even unconsciously, use them to fuel their own personal hopes for renewable energy or personal passions favoring oil companies. During this process the engineers could step in as advisors to policy makers as it is often done. However, the experts could often be tempted to hide some uncertainties in some results and overstate the importance of uncertainties in other results during the advising process. In fact, each engineer is often specialized in his/her own field and consequently he/she will be more passionate regarding his/her own specialization, such as nuclear engineering. The creation of expert figures with broad backgrounds could help in this regard. However, the final decision is in the hands of policy makers who are limited in their understanding of uncertainties. We could ask what would happen if the decision is in the hands of engineers as in a technocratic form of society. The risk of this approach would be that engineers would downplay the social consequences and have overconfidence in technologies, which is the opposite effect (and potentially even more dangerous) of decision makers who overstate the social consequences and put confidence in technologies with low performance (such as renewables).

A simple solution to this dilemma, whether energy policy decisions should be taken by scientific experts alone or by policy makers who often come with little scientific background, does not exist.

Engineers should limit their work to convey all possible data in an honest way, with the expectation that other engineers will do the same in their respective fields and that the public or policy makers will listen to experts' analysis. However, these expectations are often unfulfilled.

The creation of mixed figures such as policy makers with technological backgrounds could be a possible improvement. However, a division of roles in the decision making process between policy makers and engineers must be preserved to clearly identify who should have an unbiased scientific opinion and who should consider socio-political aspects during decision making.

17.2.3 Greater Public Good and Rationality, by Denia Djokic, University of California, Berkeley

In a society comprising many stakeholders, there is no consensus on the definition of the "greater public good." For the case of each stakeholder, this utilitarian construct is based on a certain combination of: information, misinformation, different ways of interpreting the same information, lack of information, and most of all, different value systems, some of which do not always fit into the neat frame of a traditional cost-benefit analysis.

In student discussions at this summer school, we tried to delve deeper into the meaning and function of the cost-benefit analysis. We asked questions such as whether seemingly "irrational decisions" were merely a different framing of the same cost-benefit analysis, where different stakeholders (e.g., nuclear engineers in contrast to the public) simply weigh the risks and the benefits differently. There is no simple answer, and furthermore I have no doubt that the solution depends on much more than just "communication" between the stakeholders. A good first step, however, is to encourage this kind of thought among the population that has traditionally been a major influence in top-down decisions: the nuclear engineering community.

All these insightful and fruitful discussions at the summer school made me wonder: why is it that we nuclear engineering students are not usually challenged to think this way? We seem to be well trained in our field, and yet there seems to be a very large gap in our education.

Undoubtedly, nuclear engineering students from UC Berkeley and the University of Tokyo are well educated in the breadth and depth of the discipline. However, in my nuclear engineering graduate school training to date, I have found that we are groomed to be inside-the-box thinkers without the necessary training to understand nuclear issues holistically. To solve technical problems, we are taught to draw clear boundaries around a limited problem, because without a clear definition, you cannot find a solution. Despite the fact that this method of solving problems often breaks down when scaling up to societal levels, the rhetoric among nuclear engineers as a community seems to remain along the lines of either “do what we say, we are the experts,” or “if only we could make our data and methods clear enough, the public would understand and accept nuclear power.” Any discussion as to whether our assumptions about society could be wrong seems rarely encouraged in a traditional educational setting for nuclear engineers. As a result, students easily adopt this overbearing rhetoric from our role models, and then from each other, feeding the “hubris of the engineer” (as mentioned in Prof. Kastenberg’s lecture). It has only been in this summer school that I have been formally (i.e., in an academic framework) asked to think about how to break this cycle.

Many senior figures in the nuclear industry or academia seem to try to groom students to become advocates of nuclear power, rather than educating us to be holistic thinkers on top of being experts in our field. Unfortunately, too often in the greater nuclear engineering community, the issues surrounding the implementation of nuclear energy, from siting power plants to waste disposal sites, are brushed off as “a social issue.” Statements like that usually have the flavor of an afterthought. Such a paradigm has bred a nuclear engineering community, in Japan and elsewhere, which was unprepared to meaningfully interact with the public and understand its views and fears.

Our traditional engineering training tells us there is one “right” way to view a problem, and that we engineers are the only ones who understand the “true” way to come up with a solution. I think we need to continue to challenge the traditions as we have done in this summer school, students, organizers, and lecturers alike. Specifically in the nuclear engineering field, academic research and thought is still intimately tied to the rigid nuclear industry (to varying degrees in different countries). After a major shakeup of our discipline’s foundations at Fukushima, both literally and figuratively, the necessity of introspective, “blue-sky” discussions has never been more obvious to me. Something is flawed in our discipline, and we need to start by opening new avenues within our community’s academic and educational philosophy. This summer school has been an invaluable step in the right direction.

17.2.4 Role of Nuclear Professionals After Fukushima, by Kenta Horio, the University of Tokyo

The Fukushima nuclear accident caused a significant impact on Japan. Many people were forced to evacuate from their homes, energy shortage deeply affected the economy, and people’s distrust of nuclear energy has become tremendous. Also, there are a lot of difficult tasks to be done by nuclear professionals, such as stabilization of the accident, clean-up of contaminated areas, ensuring and improving safety of existing nuclear power plants, recovering melted fuels, and decommissioning damaged reactors.

Whether we will continue to use nuclear energy in the future or not, rebuilding confidence in the general public is essential for us nuclear professionals, since we already have hundreds of reactors all over the world. In order to rebuild confidence in the general public, we have to reconsider our role in society. The conventional role of nuclear professionals in society was to provide technical information about nuclear energy, such as risk analysis, cost-benefit analysis, etc. How did we conduct this role? Was it sufficient? Or are there any other roles which we should perform for society? These are questions which we have to think about and find some answers.

I'm still convinced that the conventional role of nuclear professionals, providing information, is essential, since people need reliable, technical information to make decisions on nuclear policy and energy policy. But I also consider we have to be much more sensitive in our attitude towards the general public. Most technical information, such as simulations, calculations, or forecasts, contains some sort of uncertainties and assumptions which do not appear clearly when the outcomes are shown as numbers. Though some people are not accustomed to dealing with uncertainties or assumptions, we have to explain technical information, including uncertainties and assumptions, in a sincere and honest manner. Otherwise, information won't be truly meaningful and we won't be trusted in a real sense.

In addition to the above conventional role, I'm wondering if there are other roles which we should play. Since the culture of engineering is utilitarianism, our strongest assets and tools are based on a utilitarian way of thinking. But utilitarianism is not the only philosophy of modern society, especially in current Japan, and there are other major social values. Though I'm not sure whether it is possible to justify use of nuclear energy without utilitarianism, it might be our role to facilitate discussions among people with different sets of values and to help them to bridge the gaps. At least, we have to understand various social values and gaps among them.

The above are my thoughts on our role in society after Fukushima and I haven't yet reached any concrete conclusion. But at least, I have no doubt that we have to play a certain role in society and I consider we have to keep thinking about what our role is, not only with engineering methods but also with social scientific literacy.

17.2.5 Risk Analysis and Public Confidence, by Naomi Kaida, the University of Tokyo

In this summer school, lecturers and students proposed various arguments. In this essay, however, I would like to focus on two points: one is an answer to the question posed by Professor Kastenberg, and the other is an extension of the discussion among the students. The construction of this essay is as follows. Firstly, a response to the question is proposed. The question is about improvement of risk analysis and avoiding loss of public confidence. Secondly, further thoughts about the discussion are suggested. The main point of the argument is the relationship between social decision-making and nuclear engineers. One of the students said that it was society that would make a decision about whether to stop using nuclear power, and he would obey the social determination as an engineer. However, this essay suggests that the social/technical dichotomy is meaningless. Finally, an integrated idea of the whole is demonstrated: to construct or reconstruct public confidence, arguments in more detail among nuclear engineers are needed.

Professor Kastenberg posed some interesting questions, and one of them is, "What would it take to improve the quality of risk analysis and emergency planning so that the loss of public confidence could have been avoided?" Regrettably, risk analysis on nuclear power plants and emergency planning has not been sufficient in Japan. Emergency planning has been especially weak because power utilities had stressed that there was almost no danger that severe accidents at nuclear power plants would occur in Japan. Moreover, conducting emergency planning had been regarded as acknowledging the possibility of severe accidents at nuclear power plants. This caused weakness in emergency planning in Japan. Therefore, in order to avoid the loss of public confidence, or to reconstruct public confidence, information about risk and what will be done in case of emergency must be released to the public. Although it is too late to gain public confidence after the Fukushima accident occurred, disclosure is still needed not only by Japanese, but also by people all around the world.

Disclosure is an important keyword when people think about public confidence in nuclear power, but I would like to point out one more significant way of thinking. It is about the relationship between society and technology. In the discussion among students, one student said that it was society that would make the decision whether to stop using nuclear power in Japan, and if the public decided to withdraw from using all of the nuclear power plants, he would abide by the decision. However, I felt somewhat puzzled by his words, because he seems to assume that withdrawing from using nuclear power is not a technical but a social issue. Is it a purely social problem or a purely technical problem regarding the Fukushima accident and nuclear power policy in Japan? For instance, the emergency workers' dose limit, transmission of information, the radiation level for school playgrounds, etc.: every problem revealed has aspects of both social and technical problems. Why is only the withdrawal issue regarded as a purely social problem? When people think about the Fukushima accident and the future of nuclear power in Japan, the social/technical dichotomy is useless. Therefore, not only the public but also nuclear engineers have to discuss whether to stop using nuclear power and how to realize a safe phasing out of nuclear power.

As shown above, I think disclosure and in-depth discussion among nuclear engineers are necessary to achieve public confidence on nuclear power. While doing so, engineers should not think of society and nuclear technology separately. Public suspicion about nuclear power is becoming worse. People suspect that engineers, utilities, and the government suppress the facts about radioactive substances. In order to rebuild public confidence, unprecedented discussions and suggestions have to be proposed by nuclear engineers. For example, how to stop using nuclear power safely, how to renew or do away with nuclear power plants.

17.2.6 Benefits Versus Risk, by Keisuke Kawahara, the University of Tokyo

I was wondering whether nuclear power can be acceptable to the public. So I chose the question from Dr. Samuel Walker: "Are the benefits of nuclear power worth the risks?" The answer is "yes" from engineers, but "no" from the public side.

Engineers have been making efforts to assess costs quantitatively using risk benefit analysis. This analysis, which can be applied at probability from 10^{-4} to 10^{-6}, is regarded as the most effective and persuasive method to justify nuclear power so far. However, the public seems to be unable to accept using the analysis and cutting off the risk below 10^{-6} considering that there still exists a possibility for accidents to occur. This kind of discrepancy can be found between engineers and the public, though it is not realistic to take into account something that would hardly ever occur. There are three points which generate this discrepancy.

First, cut-off risks below the probability of 10^{-6} are decided by engineers, regarding such a probability equal to a natural disaster that should be socially acceptable. However, the cut-off line may not be acceptable to the public, because the outcome of the accident is related to human activities, even if its initial cause was due to a natural disaster. In addition, from the Fukushima accident, the public realized again that the damage from the nuclear plant was so huge that they might get less and less tolerant of accepting such a way of thinking.

Second, the difference in accidents between nuclear power and other risks is that the damage from nuclear power is concentrated in space and time. This character of nuclear power accidents increases the risk which the public feels from the perspective of fairness and makes people more emotional. In that case, the public cannot calculate the risk as "probability times damage" and risk overwhelms the benefit.

Finally, it is difficult for the public to judge results of quantitative analysis. The public reacts sensitively to risks and makes irrational choices while we engineers ask them to accept quantitative judgments. But making irrational choices is human and making rational choices is inhuman, which hinders accepting decisions based on quantitative cost-benefit analysis.

I could not come up with a clear solution to such a discrepancy from attending this summer school but can only recognize what lies between them. Widening the territory of risk benefit analysis is not meaningful, and it would be hard for the public to completely accept the analysis. However, it must be meaningful to be aware of the discrepancy and, by understanding this condition, both engineers and the public can walk together through the tough path of risk communication. If the benefits of nuclear power exceed the risk from the public side, that is not from conventional risk communication based on risk benefit analysis but from communication taking into account such a discrepancy.

17.2.7 Was Mr. Yoshida Ethical? by Lukis MacKie, University of Tennessee, Knoxville

During his lecture, Dr. Jun Fudano of the Kanazawa Institute of Technology posed a rather deep question to the students: "Was Mr. Masao Yoshida ethical?" The answer is yes.

Mr. Yoshida is the plant manager of the Fukushima Daiichi Nuclear Power Plant and was on site in the time immediately following the March 11 tsunami. When the ability to cool the reactor's nuclear core with fresh, clean water was lost, the plant workers began pumping salt water through. While salt contacting the fuel rods would accelerate their deterioration, this solution was preferable to not cooling the nuclear material at all.

This action was reported to the highest levels of the Japanese government and began to trickle down the Tokyo Electric Power Company's (TEPCO) senior management. Aware that the central government was concerned with some possible negative ramifications of this endeavor, TEPCO's executives leaned forward and directed salt water cooling activities to cease. Mr. Yoshida received this order and not only decided to ignore it, but misled his corporate leadership by telling them that salt water was no longer being pumped onto the reactor cores.

According to the Josephson Institute of Ethics: "Ethics refers to principles that define behavior as right, good and proper. Such principles do not always dictate a single 'moral' course of action, but provide a means of evaluating and deciding among competing options." (Josephson Institute of Ethics. "Making Ethical Decisions". Web. 2011).

Some are questioning Yoshida-san's ethical fortitude because he disobeyed an order from his leaders while at the same time actively deceiving them. It is reasonable to believe that if he disobeyed the order and informed those up his chain of command that he planned to continue cooling the reactors with salt water, he might have been given more external "assistance" than he desired. It is not unreasonable to believe that, if he had informed them of his actions, TEPCO's upper management might have removed him from his post and replaced him with a "yes man."

If Mr. Yoshida had followed orders and ceased using salt water cooling, it is almost impossible to conclude that the outcome would have improved. If no coolant had been used, the meltdown would have accelerated drastically. This would likely have caused considerably more damage to the surrounding area, and quickly raised radiation levels in the plant too high for personnel to continue working. While contaminated seawater was released back into the ocean, this should be seen as the lesser of two evils and the more desired result given the seemingly only other alternative.

During a crisis, particularly one that is evolving and growing more dangerous by the hour, it is often ill-advised to remove/replace essential personnel and increase bureaucracy. Micro-management from personnel more concerned with politics and less knowledgeable about the full spectrum of events on location can slow down time-critical decisions drastically.

Removing the on-site commander can be just as devastating—but sometimes it is necessary. A new commander most probably lacks the history and important details of how the situation reached its current point in time, and back-briefing him or her will cause delays. However, if the person currently in charge has proved incapable of handling the situation properly, a replacement (hopefully an early replacement) is needed.

If Yoshida had informed upper management of his plans to continue using sea water as the coolant, they might have decided a replacement capable of following orders was necessary and the best solution for the emergency at hand.

Masao Yoshida was the right person for the job. While it is probable that other TEPCO employees with thirty-plus years of experience could have managed the situation properly, none would have known the plant as well as he, nor would they have been there from day zero. By continuing to pump sea water through the reactor core, Mr. Yoshida controlled the radiation leakage as best he could. By lying to his superiors, Yoshida-san controlled the entire situation as best as he could.

Some members of the public, and certainly some members of TEPCO, are questioning Yoshida's ethics because he did not follow instruction and he lied to his leadership about it. Just as the Josephson study stated, the plant manager was left to decide "… among competing options."

Based on his experience and on-site knowledge of the situation, Yoshida-san made the call to continue using salt water to cool the reactor and deceive his leadership. Those judging his principles could see this as two ethical failures.

However, anyone questioning him must be asked one thing: If Yoshida had stopped using salt water to cool the reactor—or continued using the salt water but been truthful with his leadership, which might have resulted in his swift removal—the radiation contamination would have been much worse. If this had occurred, would you be questioning his ethics then?

Mr. Yoshida acted ethically. He had an understanding of the ground zero situation better than any member of his senior leadership, and better than any member of Japan's central government.

Given all the factors, he made the decision that he believed would result in the lowest possible radiation dose to his employees and his countrymen. He disobeyed and misled those above him; he shepherded the plant workers below him and the civilians who had no say in the matter but needed him to keep them as safe as possible.

Question Mr. Masao Yoshida's loyalty to TEPCO. Question his faith in the company's senior executives. And, if you choose, question his ethical fortitude. And when you are done second guessing his ability to determine right from wrong, thank him for the decisions he made.

17.2.8 Safety Culture and the Accident, by Hiroshi Madokoro, the University of Tokyo

My essay is a response to the question raised by Prof. William E. Kastenberg: Was there an adequate "safety culture" in place prior to and following the accident?

I think a "safety culture" existed before the Fukushima disaster, but not an adequate one. Most of us believed without doubt that we had done enough preparation for accidents. Some people argued that there is a certain probability for an accident to occur, but preparation was not sufficient. I wonder why people didn't do anything to prepare for a future accident. I think this has something to do with Japanese people's behavior.

Through discussions in this summer school, I found out there is something in common in Japanese people's minds. Japanese people tend to pursue comfort more than people in other countries do. We don't like to think about tiresome things. That is our usual behavior, but what was bad was that we also took such an attitude even toward safety management. This is one of the causes that worsened this accident. We avoided discussing "accidents," because we don't like to hear words like "accidents" or "risks" and because we assumed that a terrible event never occurs.

What is important is that we have to think about normal culture and "safety culture" separately. I heard that, even in the U.S., safety culture is different from normal culture. As I wrote above, Japanese people always want to be in a comfort state and avoid thinking about troublesome matters. However, because the Fukushima accident has occurred, we'd better change our attitude. We should no longer take this attitude toward nuclear safety. People involved in safety management need to know this culture and our behavior, and take pains to think about safety management and regulations as much as they can. I insist that "safety culture" cannot be a universal law, but the idea of "safety culture" can be generalized throughout the world. When we think about "safety culture" in Japan, we should not just import the safety culture of the U.S. or other countries. It is better that we import the concept of "safety culture" from the U.S., and then adjust it to Japanese culture, as we consider our culture. Also I conceive that each culture cannot be altered. Neither can the way people at large think and act. It is the particular people who take part in nuclear programs who should change.

People engaged in safety management or regulation need to take pains for the safety of nuclear energy, even though the probability of a terrible event is very low. It is hard for them to do so because of our culture. However, it is our responsibility to make nuclear energy safer and safer.

I believe that Japan can be an exemplar of safety to developing countries that do not yet have the idea of "safety culture." Each of the developing countries that introduce nuclear power within a few decades need to adjust the concept of "safety culture" to their country. In that process they can refer to the Japanese case.

17.2.9 Information Sharing at the Accident, by Haruyuki Ogino, the University of Tokyo

My essay responds to the lecture by Prof. Satoru Tanaka. I would like to describe how to improve the transmission of information by giving two illustrations of crisis communication implemented after the Fukushima nuclear accident. One is the press conference and the other is the distribution of information through the web.

With regard to the press conference, first of all, the spokesman should be trusted by the public and should be a person who can take responsibility. In this context, he or she should be a politician. Furthermore, the information should be given not only by the spokesman but also by experts in order to deliver precise information to the public and to meet the demand of reporters. Misunderstanding due to ambiguous explanations by a non-professional can lead to harmful rumor and panic. Taking these aspects into account, the press conference after the Fukushima nuclear accident should have been given in cooperation with both the chief cabinet secretary and experts from such agencies as the Nuclear Safety Commission of Japan, at the same time and place. We discussed the above useful and transparent communication in an emergency situation, and the American students also agreed on this point in the summer school.

The next illustration is the distribution of information through the web. After the accident, a huge amount of information was distributed day by day through the web about the reactor conditions (e.g., temperature, pressure, water level) and environmental conditions (e.g., radioactivity concentration in air, dose rate, surface contamination density). In other words, the public with access to the web was exposed to this huge amount of information without explanations of how to understand and act on it. Of course it is very important to disclose all information, but the sender should always pay attention to the recipient when information is sent out. In this context, the sender should have added the essence or intelligence that summarized the huge amount of information. We should also pay attention to the problems of how to deliver the information to the public without access to the web, such as evacuees. One solution may be a newsletter to the evacuees that summarizes the current situation on reactor and environmental conditions. This information should be delivered to those who really need it for their lives near the site.

Finally, what is needed when the information can be transmitted smoothly is "public trust" over nuclear safety. The loss of public trust was widely discussed in the summer school and we know that it will be extremely difficult to restore it in a short period of time. Thus it is our responsibility as the younger generation to keep going to achieve the long-term goal.

17.2.10 Risk Perception and Communication, by Petrus, Tokai University

After the Fukushima accident caused by the tsunami on March 11, the public had lost their trust in the safety of nuclear power plants. But, as we have seen in many disasters, people will not protect themselves if they don't believe their lives are at risk. Changing the way people perceive danger is an important way to save lives. To change the way people think, we must have specific plans for communicating the risks of dangers they could probably face.

"Sharing" is one of the ways to know how the public thinks about nuclear power plants before and after the accident. The public is not monolithic. Some people will be directly affected by the risk and some will be indirectly affected. We have to share all of the information transparently, not only information about safety but also about the risk of nuclear power plants that might result when the nuclear power plants operate. It's difficult to make people perceive this risk, because the public has realized that it is not true that "NPP is absolutely safe" or "safety first" is the foundation of nuclear plants. In this condition, engineers can take a role to improve the safety and design to make plants as safe as possible.

Understanding a public risk typically involves the range of benefits and costs associated with nuclear power plants. All aspects of the risk need to be thought through and explained, or the dialogue about the risk may become dominated by one part of the analysis. This risk-benefit analysis can be used as our tool to help us demonstrate the limit of the public risk. However, transparency of the information is better than "hiding" the information from the public. Lack of information may cause one to have exaggerated fears regarding the possible risk of a certain situation. Without factual information, we make uninformed decisions.

If the risk is considered to be the government's or the local government's responsibility, then our role as engineers may be more to coordinate and to support rather than to take responsibility. In this case, public trust in the government also plays a major role. When the government and engineers are not highly trusted, for example after the accident, we can only share accurate information, whether or not the public can take it in. Deliberative processes can provide an inclusive way of involving the public in seeking their views but these also need to be fair.

17.2.11 Radiation Risk Communication, by Kazumasa Shimada, the University of Tokyo

My essay is to respond to questions raised by Prof. Kosako related to the issue of radiation risk communication and estimated number of cancer deaths based on the collective dose.

Calculating the number of cancer deaths based on the collective effective dose caused by very small exposure to a large population has a very huge uncertainty because, statistically and biologically, it is incorrect usage of the amount of protection (ICRP, Pub.103, paragraph 161).

On the other hand, the Chernobyl Forum (performed in several international organizations; IAEA, WHO) reported that targeting about 600,000 people [decontamination personnel (average. dose is 100 mSv), evacuees (10 mSv), most contaminated local residents (50 mSv)], the number of deaths is expected to be 4,000 people and targeting about 6,800,000 people [public and workers (average dose is 7 mSv)], the number of deaths is expected to be 9,000 people (Chernobyl Forum, Chernobyl's Legacy: Health, Environmental and Socio-economic Impacts and Recommendations to the Governments of Belarus, the Russian Federation and Ukraine. IAEA, 2005). In addition, in the report of Cardis in 2006, it is said that the number of deaths is expected to be 16,000 people (CRIEPI, health effects of Chernobyl Research Center for Radiation Safety Accident http://criepi.denken.or.jp/jp/ldrc/study/topics/20060904.html).

The Fukushima nuclear accident was evaluated to be INES level 7. Therefore, calculation of the number of cancer deaths based on collective dose is unavoidable. If someone calculates the number of deaths based on radiation by this accident as a few hundred people, how is this to be explained to the public, especially the people of Fukushima? At this time, we have no answer to the question: "How do I know if my child will be one of the few hundred victims?".

Nowadays, we cannot identify whether this cancer is due to radiation. In the future, some cancer patients will likely go to court about the Fukushima nuclear accident. If the court decides to accept a causal connection between low dose and cancer, I am concerned that all cancer will be viewed as radiation. This situation is like the atomic bomb case.

In my opinion, it is against humanism to calculate the number of deaths. We should rethink the meaning of low dose radiation risk.

I propose to develop two things. One is a total health risk evaluation. The other is a minus-dose evaluation. The total health risk evaluation is to be considered with radiation, ultra-violet ray, chemical material, mental stress, etc., to evaluate human health risk. Nowadays, only the radiation risk is evaluated quantitatively and gives some cause for anxiety. Therefore, it is important to know that radiation is not a special cancer risk compared with other risks even if this evaluation has a huge uncertainty. Moreover, minus-dose evaluation is more important. Today, Linear Non-Threshold model (LNT model) can evaluate the cumulative radiation risk forever. Therefore, people have no way to escape radiation to reduce risk. On the other hand, we can find protection functions in our body, for example DNA repair, apoptosis, radioadaptive response, and immunity. This means radiation damage in our body is continually being repaired by these functions. To make quantity evaluations of these functions we can calculate that the dose was canceled by these minus-doses. For example, to increase our immunity function to reduce cancer risks quantitatively, we use methods of ordinary health promotion (for example, spas) so that our radiation risk will be canceled and our health will actually become better.

17.2.12 Benefits Versus Risks, by Kampanart Silva, the University of Tokyo

Are the benefits of nuclear power worth the risks? The question raised by Dr. J. Samuel Walker stimulated me to write this essay. There are some questions which needed to be and *could be* answered in order to specify the scope of the decision making and finally move toward the progress of answering the question.

Where is this question asked?

If it is asked in developed countries, such as the U.S. or Japan, with the money and resources that those countries have, and the high level of education of the population, there are a number of choices for electric power supply and the population has the ability to correctly select them. Therefore, we can easily move to the next question. However, if it is asked in developing countries, where rapid energy growth is a requisite condition, and the population does not even know what would be the consequences of their choices, there comes another question very difficult to answer: is it ethically preferable to ensure their rights to select the energy sources?

To whom is this question is asked?

If it is asked of an individual, and if that individual is an expert, he (or she) might try to quantitatively analyze the risk and the benefit based on the data he has, include some of his personal perceptions, and finally give you the answer. (Perhaps this is also what I am going to do.) If not an expert, he might emotionally give you the answer based on the information he has. But when it comes to a decision of a country or a society, apart from achieving the utility (by quantifying the risks and the benefits and make sure that the benefits are worth the risks), the fairness among the society members must also be taken into account by some means or other.

When is the answer needed?

In the case of decision on the energy policy of a country, when it has money and resources, which means it has the chance to choose its preferred energy resources, the answer to the question "are the benefits of nuclear power worth the risks?" might not be needed until the next decade or even the next century because its energy production potential is several times the demand. On the other hand, for a country with small potential, it might need the answer within several years or even several months. In that case, the only thing it can do is to try to improve and make use of the tool (risk-benefit analysis) it has, and set up some system to obtain as much as possible the perceptions of its public.

Under this circumstance, regarding the results of risk-benefit analysis being done by developed countries, even after including the social impacts (public anxiety or opposition movements) or ethical issues (which came up in the answer to the first question) to be observed, I still personally think that the benefits of nuclear power in Thailand are worth the risks, for the time being. However, this is based on the present information I have. If in the future, the possibility of severe accidents is to become tens or hundreds of times what we see now, and the social and economic impacts are proved to be much larger than what they are now, this evaluation may change. In my personal view, the most important thing is to be able to judge the risks and benefits under the present circumstance with limited information, and take responsibility for the judgment, no matter whether you are an individual, an expert, or a decision maker.

17.2.13 Benefits of Nuclear Power, by Christina Novila Soewono, Tokai University

The nuclear accident that occurred at Fukushima, Japan, has brought people's attention to the risks of nuclear power. While there had not been direct human cost in deaths because of the nuclear accident itself, people once again are faced with the question whether nuclear power benefit is worth the risks. It is natural to fear what you cannot see and many people do not find enough reassurance in being told that they are not at risk from the radiation that had been released.

With the rate of increasing demand of our current energy needs and the ineffectiveness of current methods, I will say that nuclear power is worth the risk. By agreeing that nuclear power is worth the risk, I am not saying that nuclear is completely safe nor that there are no alternatives, but I agree that nuclear is the better alternative and therefore worth it.

So far there have been no confirmed casualties of deaths directly attributed to the Fukushima nuclear accident. This showed us that despite the old age of Fukushima Daiichi nuclear reactor, nuclear power plant safety has been greatly improved since the Chernobyl accident. There were 64 confirmed deaths from radiation and a prediction of 60,000 cancer deaths as a result of fallout from Chernobyl. Though it is hard to predict the number of cancer deaths caused by radiation exposure, since precautionary action had been taken to protect the public, I believe that the predicted number of cancer deaths is going to be a lot fewer than Chernobyl.

The Fukushima nuclear accident has induced fear and inconvenience to the public, especially those who lived near the Fukushima site. The feelings of insecurity, unsafeness, inconvenience, and other effects are difficult to measure. The interesting part is that so far I think that coal power is far more dangerous to human life and long-term health issues than nuclear power. A coal powered plant releases more radioactivity than a well maintained nuclear power plant. In addition to that, a coal powered plant releases more pollutants, especially gases which contribute to global warming. Since coal is likely to be more hazardous than nuclear we should fear coal more than nuclear. And yet, people seem to be more comfortable with coal power plants than nuclear power plants.

Due to its effectiveness in producing energy on a large scale and ensuring energy security, I think that nuclear power plants are economically worth the risk. Japan did not have enough natural resources, which was the reason why Japan developed nuclear as an energy source during the postwar period in the first place. The energy availability in Japan supported industries which then led Japan to be the first Asian developed country that succeeded in catching up with Western countries.

Nowadays people have started to develop renewable energy that not only can be used to produce electricity but also is environmentally friendly. Unfortunately, if renewable energy sources such as wind and solar are used as energy with current technology, they are not only unreliable, but also not useful in some geographic areas due to weather patterns. Since not many people are familiar with the use of renewable energy, the cost of generating electricity is relatively high. I do believe that in the future we can overcome this problem faced by renewable energy and finally have a clean energy source. Until then, however, it is good to use nuclear power which I think is more reliable and cost effective.

17.2.14 Who Am I? What Is My Own Role on Earth? by Shin-etsu Sugawara, the University of Tokyo

This summer school has posed these challenges to me. During the last presentation of our group, a question from Dr. Juraku was of grave significance to me: what is *your* role?—not the role of "engineer" as a general noun.

This reflection shows my own reply to this.

Throughout the full program of this summer school, the "limitation" of cost-benefit analysis and the "irrationality" of social decision-making were major topics of discussion. In particular, our group focused on the issue of how nuclear engineers provide their expertise in society under conditions where the decision-making methods about energy policies look so "irrational" from their point of view in Japan and in some other countries.

Re-examining this discussion, however, I now think that our framing was too narrow and too ironical. That is because engineers' activities, which are said to be based on "rational" thoughts, failed to control nuclear technology, and as a result made society "irrational." In other words, it is engineers who want to "improve" society that drive society toward the opposite direction.

This is applied not only to the Fukushima accident but also to all the failures, misconducts, and "unexpected" accidents which are related to science and technology. And, this is not valid simply for each engineer but for all the persons and organizations who stand on the side of promoting science and technology.

These FACTS are, I think, the biggest "failures" of engineers and the points which should be considered to be the responsibility of everyone concerned with nuclear technology—of course including me—in the historical context.

Reflecting on these considerations, I will give an opinion of my own role.

I am not a nuclear engineer. I am a researcher tackling nuclear issues based on social-scientific methodologies. I now recognize my special role as a "boundary worker" as follows: to show available prescriptions—sometimes ideal ones—for dealing with risks associated with the social utilization of nuclear technology, including socially amplified risks; that is, to envisage and to publish the social systems where expertise is referenced appropriately in social decision-making processes; and to maintain the relationship between expertise and social decision in the face of extreme fluctuation.

Such roles have a substantial overlap with my own studies over 4 years. I can now be more confident on this point.

This is my principle in the profession of "boundary worker" between nuclear technology and society. Wherever I go after my graduation, I shall hold on to this principle.

17.2.15 The Role of Nuclear Engineers in Society, by Tatsuhiko Sugiyama, the University of Tokyo

Through the summer school, I became interested in the role of engineers in disclosing information, and I was particularly intrigued by Prof. Satoru Tanaka's question: How can we improve the transmission of information? I have reinforced my idea that this kind of topic involves some ethical issues and we cannot clearly decide what to do, especially in emergency situations. On the point of "transmission," however, I have found some problems and some ideas to improve the way information is transmitted.

In the Fukushima case, the major problem in transmitting information was that engineers or professionals were not trying to let citizens fully understand the meaning of the information they disclosed. They were mainly disclosing numerical data unfamiliar to citizens and the mass media were doing "interpretation" of these data. Moreover, press conferences were conducted without engineers or professionals. This led to multiple interpretations among citizens about "how serious is the accident?," "should we evacuate as soon as possible?," and so on.

In my opinion, engineers or professionals have to try to do what mass media are now doing and try to explain with or on behalf of politicians, especially in crisis communications. I agree they disclosed enough data in the Fukushima case. But this is not enough. In order to prevent panic or incorrect behavior, they themselves must try to let citizens understand without going through the media. They have to reconsider the role of engineers or professionals in emergency situations.

If our society allows the continued use of nuclear power, what are the attributes needed for a nuclear system in the new era? I will try to think about this question based on a concrete image/concept of the new nuclear system (reactor plant and its fuel cycle).

One factor that caused station blackout (SBO) was that the isolation condenser (IC) and reactor core isolation cooling (RCIC) batteries were not sufficient to survive for a long period. One advantage of IC and RCIC is that they can utilize vapor from the reactor to operate. But if they also need batteries to operate, I think this system is nonsense. Emergency core cooling systems should be isolated from such anxieties.

In my opinion, however robust a plant may be designed, some residual risks remain. Through the Fukushima case, we have gained some ideas on future reactor designs. But even if we adopt all these ideas, reactors will not be perfectly robust, and most of the people who are against the usage of NPPs often quote this problem. We have to clearly admit the existence of residual risk in the future design.

17.2.16 The Role of Nuclear Engineers in Society, by Eva Uribe, University of California, Berkeley

What is the role of nuclear engineers in society? As a scientist, and not an engineer, the summer school made me think about the relationship between science and engineering, and how both interact with society. During the conference, one of my colleagues, an engineer, made the observation that science is about discovery, while engineering is about *optimization.* Engineers make the knowledge of science useful to others through optimization of that knowledge to specific problems. The National Society of Professional Engineers' Code of Ethics makes engineers responsible first to society: "Engineering has a direct and vital impact on the quality of life for all people. Accordingly, the *services provided* by engineers require honesty, impartiality, fairness, and equity, and must be dedicated to the protection of the public health, safety, and welfare" (Preamble, emphasis added). The American Chemical Society also published a Chemical Professionals Code of Conduct, which establishes a primary responsibility to the public: "Chemical professionals have a responsibility to serve the public interest and safety and to further advance the knowledge of science."

While the engineering ethical code speaks of "services" to the public, the ACS code encourages scientists to "advance the knowledge of science." During the summer school, many asked the question how we could justify nuclear energy outside of the cost/benefit paradigm used by engineers to decide which problems to solve and how to solve them. My initial reaction was to justify nuclear energy based on the progress of science and the general advancement of knowledge. Very generally speaking, my opinion is that we should learn more about splitting the atom not only so that we may better control it, but also because this process is fundamental to how the universe works, and we as inquisitive beings should want to know how everything works. This kind of pursuit of knowledge allows scientists to justify research that others may consider unethical or immoral, such as embryonic stem cell research or even human cloning. During the conference, I began to understand that the engineering profession cannot be so easily isolated from public interests, even in the name of advancing knowledge, because its central creed is to *serve* the public.

The debate lies in the form that this service shall take, a dilemma not exclusive to engineering, but rather common to all professions. What happens when the experts and the public disagree about what is best for society? Who should decide?

The educated minority, or the majority? James Madison, one of the founders of the United States Constitution, wrote about this dilemma in Federalist Paper #10. Madison and many of his contemporaries believed that a strict democracy would be very dangerous, because it would allow the majority to suppress the rights of the minority simply by force of numbers. To combat such a tendency in government, they sought to found not a democracy, but a republic, in which elected *representatives* of the people govern the nation, rather than the people directly. His words, then spoken about political representatives, are also relevant to nuclear engineering professionals today when it comes to nuclear energy policy. He argues that representative government "refines and enlarges the public views by passing them through the medium of a chosen body of citizens, whose wisdom may best discern the true interest of their country and whose patriotism and love of justice will be least likely to sacrifice it to temporary or partial considerations … it may well happen that the public voice, pronounced by the representatives of the people, will be more consonant to the public good than if pronounced by the people themselves" (Federalist Paper #10). A representative must often look beyond local interests and seek to serve broader and deeper interests. But a representative is also directly responsible to the public. Engineers may be considered representatives of the public to the progress of technology. Scientists unveil what is known and what may be known, and engineers decide how this knowledge can be incorporated into people's daily lives. As representatives of the people, engineers are also directly responsible to them. But unlike politicians, who risk losing votes if they displease the public, engineers have much more at stake: the credibility of the profession, the usefulness of scientific progression, and the inquisitiveness of humankind. This is why their dedication to honesty, openness, and education is so important.